

OS ISOTOPES IN SNC METEORITES AND THEIR IMPLICATIONS TO THE EARLY EVOLUTION OF MARS AND EARTH: E.Jagoutz ¹⁾, J.M.Luck ²⁾, D. Ben Othman ²⁾ and H. Wänke¹⁾
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A new development on the measurement of the Os isotopic composition by mass spectrometry using negative ions opened a wide field of applications. The Re-Os systematic provides time information on the differentiation of the nobel metals. The nobel metals are strongly partitioned into metal and sulphide phases, but also the generation of silicate melts might fractionate the Re-Os system. Compared to the other isotopic systems which are mainly dating the fractionation of the alkalis and alkaliearth elements, the Re-Os system is expected to disclose entirely new information to the geochemistry. Especially the differentiation and early evolution of the planets such as the formation of the core will be elucidated with this method.

We are measuring Os isotopes in SNC meteorites, which may represent samples from the planet Mars, and compare this with the general isotopic systematic as observed on Earth.

The highly siderophile elements in the Earth's mantle are depleted when compared to chondrites, but occur in chondritic abundance ratios as firstly pointed out by Jagoutz et al., 1979. Allegre and Luck (1980) demonstrated that the Os isotopic composition of the Earth's mantle evolved along the chondritic evolution line. This strongly suggests that the Re/Os ratio of the mantle was chondritic throughout the evolution of the Earth. Since each of the highly siderophile elements has divers affinity to metal and sulphide phases, an equilibrium with the core contradicts the observed chondritic abundance pattern.

The moderately siderophile elements like Co, Ni, Ga, and Cu have mantle abundances close to 0.1 (relative to Si and Cl), while the abundance of the highly siderophiles like Ir, Os, Re, Au are 0.002. However the Ni/Co and the Re/Os ratios are identical to the chondritic ratios. The budget of highly siderophile elements in the Earth's mantle was attributed to a late veneer of about 0.5% CI material mixed into the terrestrial mantle (Wänke, 1981).

From the SNC meteorites there is some indications on the siderophile element pattern on Mars. Since the SNC's are magmatic rocks and the particular melting conditions are not known the determination of the element abundances in Mars' mantle is problematic. Wänke's method of the correlated elements provided the first insight in the composition of Mars' mantle. From this it was evident that the chemical composition of Mars' mantle is unlike the mantle on Earth. The moderately siderophile elements are considerably more variable in their abundances on Mars. The Ni/Co ratio is about be 5-6 on Mars compared with 21 in the Earth's mantle. Co is slightly and Ni is strongly depleted in Martian mantle when compared to Earth. Also it appears that Zn, Cu, and In have also been depleted in Martian mantle. Wänke and Dreibus (1988) attributed these observations to extraction of a sulphide phase at the formation of the Martian core.

The highly siderophile elements are also not in chondritic abundances on Mars. Chassigny, an olivine-rich SNC meteorite, has a Re/Os ratio which is about half the chondritic ratio. While the Os isotopic composition of Chassigny is considerably higher than the general range of the chondritic Os isotopes. It is evident that the Os isotopes are not supported by Re in Chassigny.

An Os evolution model for Chassigny might be embedded in a general isotopic model for the SNC meteorites. The crystallisation age (around 1.3 Ga) and the Sr isotopic composition as well as the Rb/Sr ratio of Chassigny might coincide with Nakhla, another SNC meteorite (Nakamura et al., 1982).

Most attempts to model the evolution for the SNC meteorites could not integrate the old Rb-Sr and Pb model ages with the young Nd systematic. In order to illustrate some of the problems some implications of the Nd isotopes will be discussed. In Fig. 1, a Sm - Nd isochron diagram is shown. The chondritic point which contains all bulk samples of normal stony meteorites is shown. A corresponding plagioclase-pyroxene isochron, like the isochron of Juvinas, is also indicated. The shaded areas mark in a simplified form the Earth's samples. The oceanic mantle represented by selected lherzolitic xenoliths is indicated. Shifted to the left there is the area of oceanic floor basalts. These basalts have the same isotopic composition as the oceanic mantle, but the melting process shifts these basalts to the left to lower Sm/Nd ratios. Although this melting process is not entirely understood yet, but we are able to model in an innocent first order this shift. The SNC meteorites, however, are basaltic and mainly plot on the right side of the meteoritic isochron (except Nakhla). A source for these basalts might be postulated on the far right side, but such a depleted reservoir might be very radiogenic in relatively short time. An unspecified multistage model is usually postulated for such cases. The Rb-Sr isotopic systematic as well as the Pb-Pb and U-Pb systematic of the SNC meteorites clearly show that complicated multistage models can be excluded. In the Rb-Sr system the SNC meteorites plot close to the 4.55 Ga isochron. The Pb isotopes measured in maskelite plot close to the geochron. In an concordia diagram the trend of the data also

suggests that a two stage model might comply with the data. An early differentiation and a late one. Whereas at the late differentiation the Rb/Sr ratio should not be changed drastically.

To model the Os evolution, we therefore use a two stage evolution for good reasoning. In Fig. 2 the measured Os isotopic composition is plotted on the y-axis, the slope of the line through this measured point is determined by the Re/Os ratio. At 1.3 Ga this evolution stopped and a straight line leads to the initial differentiation of Mars. The interesting result of our investigation is the slope of this line. This slope tells us with good reason that the Re/Os ratio in the source of Chassigny was a factor of 10 higher than chondritic. There might be less Re in the Martian mantle than in the mantle of the Earth as a consequence Os must be more than

Fig. 1

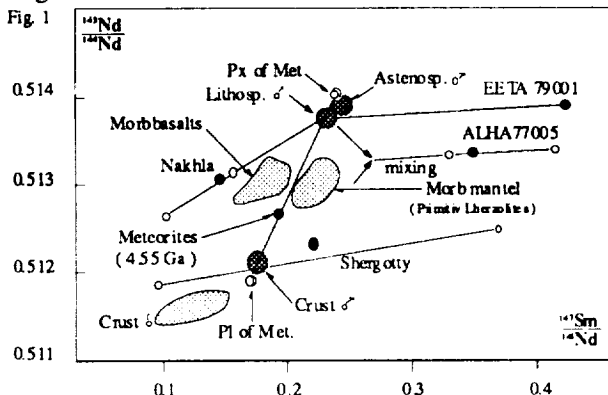
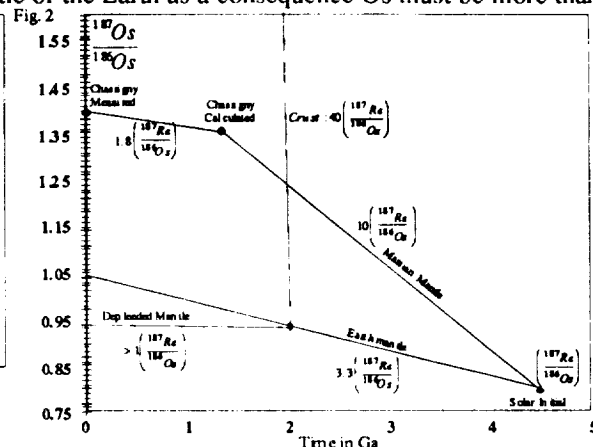


Fig. 2



a factor of 10 less. This seems to be the fingerprint of the core formation on Mars. The contrasting evolution of the Earth's mantle is also indicated in Fig. 2.

From the relative unradiogenic Sr isotopic composition of Chassigny we consider that Chassigny comes isotopically from a similar source as Nakhla. There are 3 groups of Sr isotopic composition in SNC's: 1) Nakhrites (0.704); 2) ALHA 77005 and EETA 79001 (0.71-0.715); 3) Shergotty and Zagami (0.72-0.73). These 3 groups are formed early in the Martian history which is in line with the Pb isotopes. The isotopic reservoirs formed by the early differentiation were not remixed by convection. For a number of reasons we can attribute the isotopic signature of Nakhla and Chassigny to the Martian asthenosphere (Jagoutz, 1991).

As pointed out above, the inventory of highly siderophile elements in the Earth's mantle is thought to be dominated by a late veneer. Why did the late veneer not hit Mars? It is possible that this late veneer is on Mars, but since Mars was not homogenized after the first differentiation this veneer might not be mixed in to the Martian mantle yet. Therefore we might be able to study the remnants of the highly siderophile elements in the Martian mantle just after core segregation.

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